

LXIII. *An Account of a printed Memoir, in Latin, presented to the Royal Society, intituled, De Veneris ac Solis congressu observatio, habita in astronomicâ speculâ Bononiensis Scientiarum Instituti, die 5 Junii 1761. Auctore Eustachio Zanotto, ejusdem Instituti Astronomo, ac Regiæ utriusque Londinensis et Berolinensis Academiæ Socio. By Nathanael Blifs, Savilian Professor of Geometry, and F. R. S.*

Read July 1, 1762. **T**HE planet Venus hath been so seldom observed in those circumstances, which are of the greatest use in determining some of the most essential elements of its motion, that every such observation, made by an accurate astronomer, cannot but be very acceptable to the public.

At Bologna, on the night preceding the day of the transit, the weather was very unfavourable; but early in the morning, the clouds, which covered the whole hemisphere, began to break, and were driven off towards the horizon, by a gentle wind: so that the observations were retarded only during the space of about half an hour. Father Frisi, professor of mathematics at Pisa, and Signors Mathenci and Marini, assisted in making the observations; the two latter observing, in the upper room of the observatory, together with Mr. Professor Zanotti; and Father Frisi, accompanied by the two professors of mathematics Signors Casali and Canterzani, in a lower chamber.

S. Zanotti, in order to determine the place of Venus on the Sun, made use of a quadrant of  $2\frac{1}{2}$  feet radius, in the telescope of which were placed two wires, the one in an horizontal, the other in a vertical direction: by observing the appulses of the limbs of the Sun and Venus to these wires, successively, no error from refraction can take place. But it is of no small consequence to the accuracy of these observations, that the wires should be placed truly perpendicular to each other. For this purpose, the quadrant was placed in the plane of the meridian, and a star, during its transit, was observed more than once, accurately to run along the horizontal wire. Though the position of the vertical wire was often tried by terrestrial objects, yet other methods of examination were made use of. At the same altitude, both before and after noon, the passage of the Sun not only over the horizontal, but also over the vertical wire, was observed, that it might from thence appear, whether the times of passage, when the necessary errors in observing are allowed for, were equal in both cases. In each of the following observations, the altitude is not nicely determined; because an error of one degree would occasion little or no difference in the quantity of the parallax.

The observations, fourteen in number, as given by the author, follow:

Observation 1st. Altitude  $5^{\circ} 14'$ .

H				
16	'	"		
54	37		☉'s	preceding limb at the horizontal wire.
54	$45\frac{1}{2}$		☉'s	preceding limb at the vertical wire.
56	15		☿'s	preceding limb at the vertical wire.

H

H	'	''	
16	56	20	♀'s consequent limb at the vertical wire.
	57	20	♀'s preceding limb at the horizontal wire.
	57	26	♀'s consequent limb at the horizontal wire.
	57	54	♂'s consequent limb at the horizontal wire.
16	57	55	♂'s consequent limb at the vertical wire.

Observation 2d. Altitude  $7^{\circ} 0'$ .

H	'	''	
17	5	$56\frac{1}{2}$	♂'s preceding limb at the horizontal wire.
	5	$59\frac{1}{2}$	♂'s preceding limb at the vertical wire.
	7	$25\frac{1}{2}$	♀'s preceding limb at the vertical wire.
	7	$30\frac{1}{2}$	♀'s consequent limb at the vertical wire.
	8	$35\frac{1}{2}$	♀'s preceding limb at the horizontal wire.
	8	$40\frac{1}{2}$	♀'s consequent limb at the horizontal wire.
	9	$11\frac{1}{2}$	♂'s consequent limb at the horizontal wire.
17	9	13	♂'s consequent limb at the vertical wire.

Observation 3d. Altitude  $8^{\circ} 10'$ .

H	'	''	
17	12	$50\frac{1}{2}$	♂'s preceding limb at the horizontal wire.
	12	53	♂'s preceding limb at the vertical wire.
	14	16	♀'s limb at the vertical wire.
	14	22	♀'s consequent limb at the vertical wire.
	15	27	♀'s preceding limb at the horizontal wire.
	15	32	♀'s consequent limb at the horizontal wire.
	16	4	♂'s consequent limb at the horizontal wire.
17	16	7	♂'s consequent limb at the vertical wire.

Observation 4th. Altitude  $9^{\circ} 8'$ .

H	'	''	
17	19	24	♂'s preceding limb at the horizontal wire.
	19	29	♂'s preceding limb at the vertical wire.

H ' "

- 17 20 50 ♀'s preceding limb at the vertical wire.  
 20 55 $\frac{1}{2}$  ♀'s consequent limb at the vertical wire.  
 21 57 $\frac{1}{2}$  ♀'s preceding limb at the horizontal wire.  
 22 3 ♀'s consequent limb at the horizontal wire.  
 22 35 ○'s consequent limb at the horizontal wire.  
 17 22 45 $\frac{1}{2}$  ○'s consequent limb at the vertical wire.

Observation 5th. Altitude 10° 50'.

H

- 17 29 41 ○'s preceding limb at the horizontal wire.  
 29 55 $\frac{1}{2}$  ○'s preceding limb at the vertical wire.  
 31 14 $\frac{1}{2}$  ♀'s preceding limb at the vertical wire.  
 31 20 ♀'s consequent limb at the vertical wire.  
 32 10 ♀'s preceding limb at the horizontal wire.  
 32 16 ♀'s consequent limb at the horizontal wire.  
 32 50 $\frac{1}{2}$  ○'s consequent limb at the horizontal wire.  
 17 33 15 $\frac{1}{2}$  ○'s consequent limb at the vertical wire.

Observation 6th. Altitude 14° 12'.

H

- 17 49 38 $\frac{1}{2}$  ○'s preceding limb at the horizontal wire.  
 49 42 $\frac{1}{2}$  ○'s preceding limb at the vertical wire.  
 50 55 ♀'s preceding limb at the vertical wire.  
 51 1 $\frac{1}{2}$  ♀'s consequent limb at the vertical wire.  
 51 58 $\frac{1}{2}$  ♀'s preceding limb at the horizontal wire.  
 52 4 $\frac{1}{2}$  ♀'s consequent limb at the horizontal wire.  
 52 42 $\frac{1}{2}$  ○'s consequent limb at the horizontal wire.  
 17 53 7 $\frac{1}{2}$  ○'s consequent limb at the vertical wire.

Observation

Observation 7th. Altitude  $17^{\circ} 0'$ .

H	/	//		
18	6	$3\frac{1}{2}$	○'s preceding limb at the horizontal wire.	
	6	15	○'s preceding limb at the vertical wire.	
	7	11	♀'s preceding limb at the vertical wire.	
	7	17	♀'s consequent limb at the vertical wire.	
	8	31	♀'s preceding limb at the horizontal wire.	
	8	$36\frac{1}{2}$	♀'s consequent limb at the horizontal wire.	
	9	18	○'s consequent limb at the horizontal wire.	
18	9	$31\frac{1}{2}$	○'s consequent limb at the vertical wire.	

Observation 8th. Altitude  $23^{\circ} 40'$ .

H	/	//		
18	44	$36\frac{1}{2}$	○'s preceding limb at the horizontal wire.	
	45	$15\frac{1}{2}$	○'s preceding limb at the vertical wire.	
	46	$7\frac{1}{2}$	♀'s preceding limb at the vertical wire.	
	46	14	♀'s consequent limb at the vertical wire.	
	46	$39\frac{1}{2}$	♀'s preceding limb at the horizontal wire.	
	46	47	♀'s consequent limb at the horizontal wire.	
	47	36	○'s consequent limb at the horizontal wire.	
18	48	49	○'s consequent limb at the vertical wire.	

Observation 9th. Altitude  $31^{\circ} 42'$ .

H	/	//		
19	30	15	○'s preceding limb at the horizontal wire.	
	30	22	○'s preceding limb at the vertical wire.	
	30	59	♀'s preceding limb at the vertical wire.	
	31	5	♀'s consequent limb at the vertical wire.	
	32	6	♀'s preceding limb at the horizontal wire.	
	32	11	♀'s consequent limb at the horizontal wire.	
	33	$11\frac{1}{2}$	○'s consequent limb at the horizontal wire.	
19	34	○	○'s consequent limb at the vertical wire.	

Observation 10th. Altitude  $34^{\circ} 15'$ .

H	/	//		
19	44	$10\frac{1}{2}$	○'s preceding limb at the horizontal wire.	
	44	$26\frac{1}{2}$	○'s preceding limb at the vertical wire.	
	44	$58\frac{1}{2}$	♀'s preceding limb at the vertical wire.	
	45	$5\frac{1}{2}$	♀'s consequent limb at the vertical wire.	
	45	59	♀'s preceding limb at the horizontal wire.	
	46	$4\frac{1}{2}$	♀'s consequent limb at the horizontal wire.	
	47	$7\frac{1}{2}$	○'s consequent limb at the horizontal wire.	
19	48	4	○'s consequent limb at the vertical wire.	

Observation 11th. Altitude  $37^{\circ} 21'$ .

H	/	//		
20	2	$1\frac{1}{2}$	○'s preceding limb at the horizontal wire.	
	2	14	○'s consequent limb at the vertical wire.	
	2	38	♀'s preceding limb at the vertical wire.	
	2	44	♀'s consequent limb at the vertical wire.	
	3	$46\frac{1}{2}$	♀'s preceding limb at the horizontal wire.	
	3	52	♀'s consequent limb at the horizontal wire.	
	4	$59\frac{1}{2}$	○'s consequent limb at the horizontal wire.	
20	5	49	○'s consequent limb at the vertical wire.	

Observation 12th. Altitude  $41^{\circ} 7'$ .

H	/	//		
20	23	$0\frac{1}{2}$	○'s preceding limb at the horizontal wire.	
	23	$1\frac{1}{2}$	○'s preceding limb at the vertical wire.	
	23	18	♀'s preceding limb at the vertical wire.	
	23	$24\frac{1}{2}$	♀'s consequent limb at the vertical wire.	
	24	$41\frac{1}{2}$	♀'s preceding limb at the horizontal wire.	
	24	48	♀'s consequent limb at the horizontal wire.	
	26	0	○'s consequent limb at the horizontal wire.	
20	26	36	○'s consequent limb at the vertical wire.	

Observation

Observation 13th. Altitude  $44^{\circ} 10'$ .

H	/	//	
20	40	16	☉'s preceding limb at the horizontal wire.
	40	22	☉'s preceding limb at the vertical wire.
	40	$33\frac{1}{2}$	♀'s preceding limb at the vertical wire.
	40	39	♀'s consequent limb at the vertical wire.
	41	$56\frac{1}{2}$	♀'s preceding limb at the horizontal wire.
	42	$1\frac{1}{2}$	♀'s consequent limb at the horizontal wire.
	43	$17\frac{1}{2}$	☉'s consequent limb at the horizontal wire.
20	43	$53\frac{1}{2}$	☉'s consequent limb at the vertical wire.

Observation 14th. Altitude  $46^{\circ} 28'$ .

H	/	//	
20	53	$51\frac{1}{2}$	☉'s preceding limb at the horizontal wire.
	53	$58\frac{1}{2}$	☉'s consequent limb at the vertical wire.
	54	$3\frac{1}{2}$	♀'s preceding limb at the vertical wire.
	54	9	♀'s consequent limb at the vertical wire.
	55	30	♀'s preceding limb at the horizontal wire.
	55	36	♀'s consequent limb at the horizontal wire.
	56	54	☉'s consequent limb at the horizontal wire.
20	57	$25\frac{1}{2}$	☉'s consequent limb at the vertical wire.

When the planet drew near to the edge of the Sun's disk, the observers prepared to determine the time of the two contacts, Professor Zanotti, with the telescope of the quadrant of  $2\frac{1}{2}$  feet focus, Professor Mathenci, with the telescope of 22 feet, and Signor Marini, with that of 10 feet.

The internal contact was observed

At	H	'	''							
	21	4	34	with the telescope of	$2\frac{1}{2}$	feet.				
	21	4	58	-	-	-	-	-	-	10 feet.
	21	4	58	-	-	-	-	-	-	22 feet.

The external contact was observed

At	H	'	''							
	21	22	30	with the telescope of	$2\frac{1}{2}$	feet.				
	21	23	0	-	-	-	-	-	-	10 feet.
	21	23	7	-	-	-	-	-	-	22 feet.

During the intervals of the observations made with the quadrant, the planet was always observed to be perfectly round, without any ring or nebulosity.

It may, at first sight, seem wonderful, says Signor Zanotti, that observations made with different telescopes, one of 10, the other of 22 feet, should so nearly coincide, the times of the first contact agreeing to the same second, and those of the last differing only 7 seconds, by which the contact was seen to happen so much later through the longer telescope; and the blame might be laid either upon the longer telescope, or upon the observer. The goodness of the telescope will readily be allowed, when it is known, that it was made by Campani; and the skill and dexterity of the observer are too well known, to give room for any suspicion on his part. It may rather be attributed to the near equality of the magnifying power of the two instruments; the longer telescope having an eye-glass of 3 inches focal length, and the shorter an eye-glass of  $1\frac{1}{4}$ ; by means of which,



which, the images of the Sun and Venus were nearly equal in both.

The author then proceeds to determine, by calculation, (the method of which he has at large explained) the difference of longitude between the centers of the Sun and Venus; and also the planets latitude, which, as seen from the Earth's center, are, at the time of each observation, as in the following table.

N. B. The author has not mentioned the exact quantity of the Sun's parallax, which he made use of in these computations: but, from some trials, it should seem, that he supposed the parallax of the Sun to be  $10\frac{1}{2}$  or 11 seconds.

True time, after the noon.	Difference of longitude be- tween ☉ and ♀ .	Latitude ♀ South.
H / "	/ "	/ "
16 56 17 $\frac{1}{2}$	5 46 East.	8 31
17 7 28	5 7 East.	8 40 $\frac{1}{2}$
17 14 19	4 41 $\frac{1}{2}$ East.	8 46
17 20 52 $\frac{3}{4}$	4 15 $\frac{1}{2}$ East.	8 56
17 31 17 $\frac{1}{4}$	3 36 $\frac{1}{2}$ East.	8 54
17 50 58 $\frac{1}{4}$	2 18 East.	9 0
18 7 14	1 21 $\frac{1}{2}$ East.	9 14
18 46 10 $\frac{3}{4}$	1 19 West.	9 46
19 31 12	4 19 $\frac{1}{2}$ West.	10 4
19 45 2	5 1 $\frac{1}{2}$ West.	10 13
20 2 41	6 20 $\frac{1}{2}$ West.	10 28 $\frac{1}{2}$
20 23 21	7 46 $\frac{1}{2}$ West.	10 41
20 40 36 $\frac{1}{4}$	8 46 West.	10 49
20 54 6 $\frac{1}{4}$	9 46 West.	11 0

These longitudes and latitudes do not exactly answer to the interval of time between each observation : but the observer has related them faithfully as they were taken ; and if we consider, that they were determined by time, and that an error of half a second will have a considerable influence upon each observation, it will readily be allowed, that the observations are carefully made, and agree very well together, though

though taken with an instrument of so small a radius. The following are the elements deduced from those observations, which were made at the distance of at least an hour and an half:

	°	'	"
The horary motion of ♀ in longitude -	0	3	55 $\frac{4}{5}$
The horary motion in latitude - - -	0	0	36 $\frac{3}{5}$
The true time of the conjunction of ☉ } and ♀ - - - - -	H 18	26	" 0
The latitude of ♀ at the conjunction -	0	9	27 $\frac{5}{6}$

From these numbers the author deduced the following elements, by trigonometrical calculation:

The angle of the path with the ecliptic	8	49	23
The horary motion in the path - -	0	3	58 $\frac{2}{3}$
The part of the path between the middle } of the transit and the conjunction -	0	1	27
The distance of the path from ☉'s center } southwards - - - - -	0	9	21
The length of the path within the ☉'s } disk - - - - -	0	25	29 $\frac{1}{2}$
The difference of longitude of ☉ and } ♀ at the ingress - - - - -	0	14	2
The difference of longitude at the egress	0	11	9 $\frac{1}{2}$
The latitude of ♀ at the ingress south -	0	7	17
The latitude of ♀ at the egress south -	0	11	12
The time of the middle of the transit -	H 18	4	" 6
The ingress of the center of ♀ on the ☉'s } disk - - - - -	14	51	49
The egress of the center of ♀ - - -	21	16	23

It appears also by his calculation, that the time of the internal contact was accelerated  $30''$ , and the last contact  $18''$ , by parallax. The internal contact, therefore, as seen from the center of the Earth, was at  $21^h 5' 28''$ , and the external contact was at  $21^h 23' 25''$ , and the egress of the planet's center at  $21^h 14' 33''$ .

From the time of the planet's passage over the edge of the Sun's disk, as seen from the Earth's center, the author very accurately determines the planet's diameter to be  $57''\frac{2}{3}$ .

The egress of the center of Venus, as deduced from the position of its path, and from the other elements, as related above, differs near two minutes from the observed time, when corrected by parallax, and reduced to the Earth's center. This difference is entirely to be attributed to an error in the motion of Venus in longitude, which, perhaps, could not be deduced with sufficient accuracy from these observations, and from a small error in some of the other elements; all which the author might have taken, with the utmost accuracy, from the tables either of Dr. Halley or M. Cassini. Perhaps also, some part of this difference might arise from our ignorance of the true quantity of the Sun's parallax.

Hitherto our author has given us those elements, which might immediately be determined from his observations: the following are deduced from the tables. From the the motion of Venus in latitude, it may readily be collected, that the planet was in its node on June 5, at  $14^h 55' 9''$ . The place of the Sun at that time, according to the tables of the Abbé De la Caille, was in  $\pi 14^\circ 59' 5''\frac{1}{2}$ ; and the planet's

planet's elongation from the Sun, at the same time, was  $1^{\circ} 0' 58''$ . Therefore, the longitude of Venus, and also of the node, was in  $\Pi 13^{\circ} 58' 7'' \frac{1}{2}$ . The angle at the Sun, or the difference of the longitude of the planet and the Earth, as seen from the Sun, was  $0^{\circ} 24' 15''$ . Therefore, the longitude of the descending node of Venus, as seen from the Sun, was in  $\P 14^{\circ} 34' 50''$ .

The latitude of Venus, as seen from the Earth, at the time of the conjunction, was  $0^{\circ} 9' 27'' \frac{5}{6}$ ; by solving a triangle of which, the computed distances of the Earth and Venus from the Sun constitute two sides, the angle at the Sun, or the planet's heliocentric latitude, viz.  $0^{\circ} 3' 46''$ , will be determined. With this heliocentric latitude, and the calculated place of the Sun at the time of the conjunction, and the longitude of the node, as before laid down, from two sides of a spheric right-angled triangle, an angle may be computed, which will express the inclination of the planet's orbit with the ecliptic. The place of the Sun, at the time of the conjunction, was in  $\Pi 15^{\circ} 36' 10''$ . The difference of the heliocentric longitude of the earth, and the node, was  $1^{\circ} 1' 20''$ . Therefore the angle of the inclination of the orbit of Venus with the ecliptic is  $3^{\circ} 30' 49''$ .

N. B. The several numbers contained in this paper, are taken from the correct numbers written in the margin of the printed memoir, with the author's own hand, and which seem to be the result of his latest calculations. And though his observations were made with great care, and faithfully calculated, yet the results will not be found so accurate, as could

be wished; since the latitude of Venus, deduced from these observations, is, in all probability,  $10''$  or  $12''$  too little; a quantity, which must have a very sensible influence, both on the place of the node, and the inclination of the planet's orbit with the ecliptic; the latter of which ought to be deduced from observations made on the planet, when in its greatest latitudes.

In the lower chamber of the observatory, the observers made use of two telescopes, one of 6, the other of 8 feet, furnished with wires at half-right angles, in order to determine the place of Venus on the Sun, by causing the Sun's southern limb to run down one of the threads: the following observations were made:

### Observation 1st.

H			
18	'	''	
18	11	$40\frac{1}{2}$	Sun's center at the horary wire.
18	11	50	Venus's center at the horary wire.
		26	{ The difference between the horary and oblique wires.

### Observation 2d.

H			
19	'	''	
19	24	$1\frac{1}{2}$	Center of ☿ at horary wire.
19	24	$17\frac{1}{2}$	Center of ☉ at horary wire.
		23	{ Difference between the horary and oblique wires.

Observation

Observation 3d.

H	'	''	
20	16	53	Center of ☿ at horary wire.
20	17	23	Center of ☾ at horary wire.
20			{ Difference between the horary and ob-
			lique wires.

Observation 4th.

H	'	''	
20	47	22 $\frac{1}{2}$	Center of ☿ at horary wire.
20	47	55 $\frac{1}{2}$	Center of ☾ at horary wire.
17			{ Difference between the horary and ob-
			lique wires.

Observation 5th.

H	'	''	
20	59	17	Center of ☿ at horary wire.
20	59	54 $\frac{1}{2}$	Center of ☾ at horary wire.
15 $\frac{3}{4}$			{ Difference between the horary and ob-
			lique wires.

The internal contact was observed, by three different telescopes,

At	H	'	''	
	21	4	54	with a telescope of 6 feet.
	21	5	0	- - - - - 8 feet.
	21	4	56	- - - - - 11 feet.

The external contact was observed

At	H	'	"		with a telescope of	6 feet.
	21	22	53			
	21	22	50	- - - - -		8 feet.
	21	22	59	- - - - -		11 feet.

Professsor Canterzani examined the observations by projection, and found them to agree very nearly with those made in the upper chamber by Signor Zanotti.

*E N D* of P A R T I.

# ERRATUM.

Page 198, Line 11, for *from*, read *with*.

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## ERRATUM in VOL. LI. PART II.

Page 922, Line 2, for *sum or difference*, read *difference or sum*.